

## **CLAIMS**

What is claimed is:

- 1        1. An apparatus for determining azimuth of a remote formation boundary by in a  
2        logging while drilling tool by measuring a transverse magnetic field in a down  
3        hole tool comprising:  
4        a downhole resistivity tool for traversing a well bore measuring a property of  
5        interest in a formation adjacent to the well bore, the down hole tool having a body  
6        with a longitudinal axis substantially aligned with a longitudinal axis of the well  
7        bore, the body having a external surface;  
8        a coil antenna placed near the external surface of the tool body;  
9        a groove cut in the external surface tool body and oriented horizontally with  
10       respect to the longitudinal axis of the tool body;  
11       a transmitter comprising a transverse coil placed in the grooves for transmission  
12       or reception of a transverse magnetic field; and  
13       a receiver coil antenna near the external surface of the tool body for reception of a  
14       magnetic field which is oriented substantially orthogonal with respect to the  
15       transmitter; and  
16       grooves cut in the external surface of the tool body and oriented substantially  
17       perpendicularly with respect to the antenna wire.

1    2.    The apparatus of claim 2, further comprising:  
2        a gap between the transverse coil and a bottom each groove in the plurality of  
3        grooves; and  
4        a ferrite material placed in the gap.

1    3.    The apparatus of claim 1 further comprising:  
2        a plurality of receivers; and  
3        a plurality of transmitters.

1    4.    The apparatus of claim 1, wherein the measurement further comprises:  
2        an in phase and a quadrature component.

1    5.    The apparatus of claim 1, wherein the groove measurement further  
2        comprises:  
3        a plurality of grooves.

1    6.    The apparatus of claim 1, further comprising:  
2        a gap between the coil and the bottom of each groove under both transmitter and  
3        receiver coils; and a ferrite material placed in the gap.

1    7.    The apparatus of claim 1, wherein the groove further comprises:  
2        a flat shape at a bottom of the groove.

1 8. The apparatus of claim 1, wherein the groove further comprises:  
2 a curved shape at a bottom of the groove.

1 9. A method for determining azimuth of a remote boundary by in a logging while  
2 drilling tool by measuring a transverse magnetic field in a down hole tool  
3 comprising:  
4 measuring a property of interest in a formation adjacent the well bore, while  
5 traversing a well bore with a down hole tool, the down hole tool having a body  
6 with a longitudinal axis substantially aligned with a longitudinal axis of the well  
7 bore, the body having a external surface;  
8 orienting horizontally with respect to the longitudinal axis of the tool body a  
9 groove cut in the external surface tool body and; and  
10 placing a transmitter comprising a transverse coil placed in the grooves for  
11 transmission or reception of a transverse magnetic field; and  
12 receiving a magnetic field in a receiver oriented orthogonal with respect to the  
13 transmitter.

1 10. The method of claim 9, further comprising:  
2 measuring a magnetic field with a single or plurality of receivers and a single or  
3 plurality of transmitters that are arranged substantially orthogonal with respect to  
4 the receiver(s);

5 providing a gap between the transverse coil and a bottom each groove in the  
6 plurality of grooves; and  
7 placing a ferrite material placed in the gap.

1 11. The method of claim 9 further comprising:  
2 providing a plurality of receivers; and  
3 providing a plurality of transmitters.

1 12. The method of claim 9, further comprising:  
2 measuring an in- phase and quadrature components of a magnetic field.

1 13. The method of claim 9, further comprising:  
2 processing the magnetic field data downhole from a plurality of receivers; and  
3 processing the magnetic field data downhole from a plurality of transmitters; and  
4 processing the magnetic field data downhole from a plurality of frequencies.

1 14. The method of claim 13, further comprising:  
2 measuring the magnetic field at multiple tool azimuthal angles.

1 15. The method of claim 9, further comprising:  
2 transmitting the measured and downhole-processed data uphole via a downhole  
3 data telemetry system;  
4 measuring at a first frequency; and  
5 measuring at a second frequency.

1 16. The method of claim 8, wherein the groove further comprises:  
2 providing a flat shape at a bottom of the groove.

1 17. The method of claim 9, wherein the groove further comprises:  
2 providing a curve shape at a bottom of the groove.

1 18. The method of claim 9, further comprising:  
2 processing the magnetic field data from a formation;  
3 providing a plurality of receivers to reject tool- and borehole-related artifacts  
4 including but not limited to tool bending and tool eccentricity effects;  
5 processing the magnetic field data from a plurality of transmitters to reject tool-  
6 and borehole-related artifacts including but not limited to borehole rugosity  
7 effects; and  
8 processing the magnetic field data from a plurality of frequencies.

1     19.   A computer readable medium containing instructions that when executed by a  
2           computer perform a method for determining azimuth of a remote boundary by a  
3           measured amplitude or phase component of an amplitude and phase component in  
4           a logging while drilling tool by measuring a cross-component transverse magnetic  
5           field in a down hole tool comprising:  
6           measuring a property of interest in a formation adjacent the well bore, while  
7           traversing a well bore with a down hole tool, the down hole tool having a body  
8           with a longitudinal axis substantially aligned with a longitudinal axis of the well  
9           bore, the body having a external surface;  
10          orienting horizontally with respect to the longitudinal axis of the tool body a  
11          groove cut in the external surface tool body and; and  
12          placing a transmitter comprising a transverse coil placed in the grooves for  
13          transmission or reception of a transverse magnetic field; and  
14          receiving a magnetic field in a receiver oriented orthogonal with respect to the  
15          transmitter.

1     20.   The medium of claim 19 further comprising:  
2           providing a gap between the transverse coil and a bottom each groove in the  
3           plurality of grooves; and  
4           placing a ferrite material placed in the gap.

1     21.   The medium of claim 19 further comprising:

2 providing a plurality of receivers; and  
3 providing a plurality of transmitters.

1 22. The medium of claim 19, further comprising:  
2 measuring an in phase and quadrature component.

1 23. The medium of claim 19, further comprising:  
2 measuring at a first frequency; and  
3 measuring at a second frequency.

1 24. The method of claim 19, wherein the groove further comprises:  
2 providing a flat shape at a bottom of the groove.

1 25. The apparatus of claim 19, wherein the groove further comprises:  
2 providing a curve shape at a bottom of the groove.

1 26. The method of claim 19, further comprising:  
2 providing a plurality of grooves.